PATENT ABSTRACTS OF JAPAN

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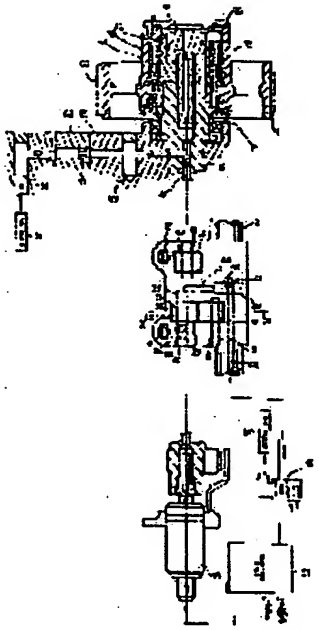
(54) VARIABLE VALVE DEVICE FOR ENGINE

(57)Abstract:
PURPOSE: To stabilize combustion and reduce fuel consumption by delaying opening/closing timings of an intake valve during low speed and low load operation time for reducing a lifting rate, advancing the opening/closing timings of the intake valve during low speed and high load operation time for reducing the lifting rate, and delaying the opening/closing timing of the intake valve during high speed operation time for increasing the valve lifting rate.
CONSTITUTION: Main rocker arms 1 are provided on a valve lift adjusting mechanism 40 corresponding to two intake valves of each cylinder, which arm I is supported to a cylinder head 69 through a main rocker shaft 3. An adjust screw 10 is arranged between the arm 1 and the intake valve. A sub-rocker arm 2 is provided with a sub-rocker shaft 16 therebetween. A valve timing adjusting mechanism 70 is arranged between a cam shaft 72 and a cam pulley 71 which receives torque from a timing belt 66. A helical gear 73 advances the cam shaft 72 by means of hydraulic pressure in a hydraulic chamber 75. The valve lift adjusting mechanism 40 and the valve timing adjusting mechanism 70 are controlled by means of a control unit 51 through solenoid changeover valves 45, 79.



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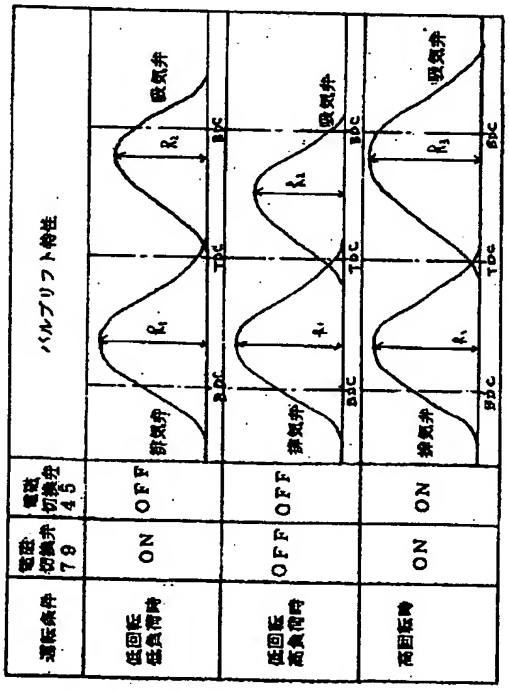
(54)【発明の名称】エンジンの可変動弁装置

(57)【要約】
【目的】　吸気弁のバルブリフト特性を運転条件に応じて適正に制御する可変動弁装置を提供する。
【構成】　クランクシャフトに対する吸気カムシャフトの位相角を変えるバルブタイミング調整機構と、互いに異なるプロフィールを有する複数のカムを選択的に切換えて吸気弁のリフト量を変えるバルブリフト調整機構を備え、コントロールユニットは、低回転低負荷時に吸気弁の開閉時期を遅らせるとともに、吸気弁のリフト量を小さくし、低回転高負荷時に吸気弁の開閉時期を進ませるとともに、吸気弁のリフト量を小さくし、高回転時に吸気弁の開閉時期を遅らせるとともに、吸気弁のリフト量を大きくする構成とする。



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【特許請求の範囲】

【請求項1】　吸気弁を開閉駆動する吸気側カムシャフトと、クランクシャフトに対する吸気側カムシャフトの位相角を変えるバルブタイミング調整機構と、互いに異なるプロフィールを有する複数のカムと、吸気弁を開閉駆動するカムを切換えるバルブリフト調整機構と、エンジンの運転条件を検出する手段と、エンジンの運転条件に応じてバルブタイミング調整機構とバルブリフト調整機構を駆動する制御手段とを備えたエンジンの可変動弁装置にあって、制御手段は、低回転低負荷時にバルブタイミング調整機構を介して吸気弁の開閉時期を遅らせるとともに、バルブリフト調整機構を介して吸気弁のリフト量を小さくし、低回転高負荷時にバルブタイミング調整機構を介して吸気弁の開閉時期を進ませるとともに、バルブリフト調整機構を介して吸気弁のリフト量を小さくし、高回転時にバルブタイミング調整機構を介して吸気弁の開閉時期を遅らせるとともに、バルブリフト調整機構を介して吸気弁のリフト量を大きくする構成としたことを特徴とするエンジンの可変動弁装置。

【請求項2】　制御手段は、吸気弁のバルブリフト特性を切換える運転時に、バルブタイミング調整機構とバルブリフト調整機構を時間差を持って切換え作動させる構成としたことを特徴とする請求項1記載のエンジンの可変動弁装置。

【請求項3】　制御手段は、低回転高負荷時から高回転時に移行する運転条件で、先にバルブリフト調整機構を切換え作動させた後、バルブタイミング調整機構を切換え作動させ、高回転時から低回転高負荷時に移行する運転条件で、先にバルブタイミング調整機構を切換え作動させた後、バルブリフト調整機構を切換え作動させる構成としたことを特徴とする請求項2記載のエンジンの可変動弁装置。

【請求項4】　制御手段は、低回転高負荷時から高回転時に移行する運転条件で、バルブリフト調整機構の切換え作動が終了した後、バルブタイミング調整機構を切換え作動させ、高回転時から低回転高負荷時に移行する運転条件で、バルブタイミング調整機構の切換え作動が終了した後、バルブリフト調整機構を切換え作動させる構成としたことを特徴とする請求項3記載のエンジンの可変動弁装置。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、吸気弁のバルブリフト特性をエンジン運転条件に応じて制御する可変動弁装置に関するものである。

【0002】

【従来の技術およびその課題】従来から運転条件に応じて吸気弁または排気弁の開閉作動に携わるカムを選択的に切換え、これにより吸排気のタイミングあるいは吸排気量を制御することが知れている(例えば特開昭63－

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167016号公報、特開昭63－57805号公報等参照)。

【0003】これについて説明すると、その揺動先端が弁に当接する低速用ロッカアームと、この低速用ロッカアームの片側に隣接して弁との当接部位を持たない高速用ロッカアームとが共通のロッカシャフトに揺動可能に支持され、低速用ロッカアームには低速カムが、高速用ロッカアームには低速カムよりも開弁角度またはバルブリフト量が大きくなるプロフィールを有する高速カムがそれぞれ摺接される。

【0004】さらに、ロッカシャフトから所定の距離だけ離れた揺動部位においてロッカシャフトと平行な方向には、作動油圧に応動するプランジャが嵌合穴に嵌まりあるいは嵌合穴から抜けることで2つのロッカアームが連結されたりその連結が解かれたりする。

【0005】

【発明が解決しようとする課題】しかしながら、このようなエンジン運転条件に応じて複数のカムを選択的に切換える従来装置にあっては、低速カムによる開弁期間は、高速カムによる開弁期間の範囲内に設定する必要があるため、例えば低回転高負荷域でシリンダに吸入された混合気が吸入行程の下死点付近で吸気ポートに吐き出されることを抑制するために吸気弁の閉弁時期を早めようとすると、開弁期間が短くなって充填効率が悪化し、低速カムから高速カムに切換わる回転数付近でトルクの落ち込みが発生するという問題点が考えられる。

【0006】本発明は上記の問題点に着目し、吸気弁のバルブリフト特性を運転条件に応じて適正に制御する可変動弁装置を提供することを目的とする。

【0007】

【課題を解決するための手段】本発明は、吸気弁を開閉駆動する吸気側カムシャフトと、クランクシャフトに対する吸気側カムシャフトの位相角を変えるバルブタイミング調整機構と、互いに異なるプロフィールを有する複数のカムと、吸気弁を開閉駆動するカムを切換えるバルブリフト調整機構と、エンジンの運転条件を検出する手段と、エンジンの運転条件に応じてバルブタイミング調整機構とバルブリフト調整機構を駆動する制御手段とを備えたエンジンの可変動弁装置にあって、制御手段を、低回転低負荷時にバルブタイミング調整機構を介して吸気弁の開閉時期を遅らせるとともに、バルブリフト調整機構を介して吸気弁のリフト量を小さくし、低回転高負荷時にバルブタイミング調整機構を介して吸気弁の開閉時期を進ませるとともに、バルブリフト調整機構を介して吸気弁のリフト量を小さくし、高回転時にバルブタイミング調整機構を介して吸気弁の開閉時期を遅らせるとともに、バルブリフト調整機構を介して吸気弁のリフト量を大きくする構成とする。

【0008】請求項2記載の発明は、制御手段を、吸気弁のバルブリフト特性を切換える運転時に、バルブタイ

ミング調整機構とバルブリフト調整機構を時間差を持って切換え作動させる構成とする。

【０００９】請求項３記載の発明は、制御手段を、低回転高負荷時から高回転時に移行する運転条件で、先にバルブリフト調整機構を切換え作動させた後、バルブタイミング調整機構を切換え作動させ、高回転時から低回転高負荷時に移行する運転条件で、先にバルブタイミング調整機構を切換え作動させた後、バルブリフト調整機構を切換え作動させる構成とする。

【００１０】請求項４記載の発明は、制御手段を、低回転高負荷時から高回転時に移行する運転条件で、バルブリフト調整機構の切換え作動が終了した後、バルブタイミング調整機構を切換え作動させ、高回転時から低回転高負荷時に移行する運転条件で、バルブタイミング調整機構の切換え作動が終了した後、バルブリフト調整機構を切換え作動させる構成とする。

【００１１】

【作用】低回転低負荷時にバルブタイミング調整機構を介して吸気弁の開閉時期を遅らせるとともに、バルブリフト調整機構を介して吸気弁のリフト量を小さくして、バルブオーバラップを小さくすることにより、排気ポートからシリンダへの排気の吹き返しを抑えられ、残留ガス率を低下させて燃焼を安定させ、アイドル安定性を高められるとともに、燃費の低減がはかれる。

【００１２】低回転高負荷時にバルブタイミング調整機構を介して吸気弁の開閉時期を進ませることにより、シリンダに吸入された混合気が吸入行程の下死点付近で吸気ポートに吐き出されることを抑制して、吸気充填効率を高められる。このとき、バルブリフト調整機構を介して吸気弁のリフト量を小さくすることにより、バルブオーバラップが大きくなり過ぎることを回避し、残留ガスを低下させ、発生トルクを高められる。

【００１３】高回転時にバルブタイミング調整機構を介して吸気弁の開閉時期を遅らせるとともに、バルブリフト調整機構を介して吸気弁のリフト量を大きくすることにより、吸気の慣性過給効果を利用して吸気充填効率を高められる。しかも、バルブオーバラップを大きくすることにより、排気管内に生じる負圧波により排気の掃気効果が得られ、排気の押し出し損失を低減して出力向上がはかれる。すなわち、排気行程の後半は排気管を移動する排気ガスにより負圧が生じるとともに、オーバラップ期間中は吸気流がシリンダ内に流入することで排気ガスの掃気効果が高められる。

【００１４】請求項２記載の発明においては、吸気弁のバルブリフト特性を切換える運転時に、バルブタイミング調整機構とバルブリフト調整機構を時間差を持って切換え作動させる構成のため、バルブタイミング特性とバルブリフト特性が段階的に切換えれることにより、切換え時に生じるエンジンのトルクショックを緩和することができる。

【００１５】請求項３記載の発明においては、低回転高負荷時から高回転時に移行する運転条件で、先にバルブリフト調整機構を切換え作動させた後、バルブタイミング調整機構を切換え作動させることにより、先に切換え作動速度の比較的遅いバルブタイミング調整機構を切換える場合に比べて、切換えに要する時間が短縮され、加速応答性を高められる。

【００１６】高回転時から低回転高負荷時に移行する運転条件で、先にバルブタイミング調整機構を切換え作動させた後、バルブリフト調整機構を切換え作動させることにより、先に切換え作動速度の比較的速いバルブリフト調整機構を切換える場合に比べて、この切換に要する時間が長くなり、急激に減速するショックを緩和することができる。

【００１７】請求項４記載の発明においては、運転条件に応じて先に切換え作動するバルブリフト調整機構またはバルブタイミング調整機構の切換え作動が終了し後、バルブタイミング調整機構またはバルブリフト調整機構を切換え作動させることにより、バルブタイミング調整機構とバルブリフト調整機構の作動終了時期に時間差を確実に持たせることができる。

【００１８】

【実施例】図２、図３は本発明の一実施例の機械的構成を示す。

【００１９】まず、バルブリフト調整機構４０について説明する。各気筒には２本の吸気弁９に対応して単一のメインロッカアーム１が設けられる。メインロッカアーム１の基端は各気筒に共通なメインロッカシャフト３を介してシリンダヘッド６９に揺動自在に支持され、メインロッカアーム１の先端には各吸気弁９のステム頂部を当接させるアジャストスクリュ１０がナット１１を介して締結される。

【００２０】メインロッカアーム１にはシャフト１３にニードルベアリングを介してローラ１４が回転自在に連結され、このローラ１４に低速カム２１を転接させるようになっている。

【００２１】メインロッカアーム１は平面図上ほぼ矩形に形成され、メインロッカアーム１にはローラ１４と並んでサブロッカアーム２が設けられる。このサブロッカアーム２の基端はサブロッカシャフト１６を介してメインロッカアーム２に相対回転可能に連結される。サブロッカシャフト１６はサブロッカアーム２に形成された穴１７に摺動可能に嵌合する一方、各メインロッカアーム１に形成された穴１８に圧入されている。

【００２２】サブロッカアーム２は吸気弁９に当接する部位を持たず、その先端には高速カム２２に摺接するカムフォロア部２３が円弧状に突出して形成され、その下側にはこのカムフォロア部２３を高速カム２２に押し付けるロストモーションスプリング２５が介装される。

【００２３】メインロッカアーム１にはサブロッカアー

ム2の直下に位置してロストモーションスプリング25を介装する円柱状の凹部26が一体形成される。コイル状のロストモーションスプリング25の下端は凹部26の底面26aに着座し、その上端は凹部26に摺動自在に嵌合するリテーナ27を介してサブロッカアーム2に一体形成されたフォロア部28に当接する。

【0024】低速カム21と高速カム22はそれぞれ共通のカムシャフト72に一体形成され、エンジンの低回転時と高回転時において要求されるバルブリフト特性を満足するように異なる形状(大きさが異なる相似形も含む)に形成されている。この実施例では、図4に示すように、高速カム22は低速カム21と比べ、バルブリフト量と開弁期間を共に大きくしたプロフィールを有している。ここでは、バルブリフト量、開弁期間を共に大きくしてある。なお、排気弁を駆動するカムのリフト量をh_1、高速カム22のリフト量をh_3、低速カム21のリフト量をh_2とすると、$h_3 > h_1 > h_2$の関係を持っている。

【0025】両ロッカアーム1，2の相対回転を係止可能とする連結駆動手段として、メインロッカアーム1とサブロッカアーム2に渡ってプランジャ33，31，34が摺動自在に嵌合され、プランジャ33の背後に油圧通路43が接続される一方、プランジャ34の背後にリターンスプリング38が介装される。

【0026】油圧通路43から導かれる作動油圧が低いと、リターンスプリング38の付勢力によりプランジャ33，31がサブロッカアーム2とメインロッカアーム1にそれぞれ収まって両者の揺動を拘束しない。一方、油圧通路43から導かれる作動油圧が上昇すると、プランジャ33，31がリターンスプリング38を圧縮しながら摺動して、メインロッカアーム1とサブロッカアーム2に渡って嵌合することにより両者が一体となって揺動する。

【0027】油圧通路43はメインロッカアーム1およびメインロッカシャフト3の内部を通して設けられ、電磁切換弁45を介してオイルポンプ57の吐出油圧が所定の高回転時に導かれる。

【0028】次に、バルブタイミング調整機構70について説明する。バルブタイミング調整機構70はカムシャフト72とカムプーリ71の間に設けられ、運転条件に応じて両者の位相角度を変えて吸気弁9の開閉時期を変えるようになっている。カムプーリ71はタイミングベルト66を介してクランクシャフト（図示せず）からの回転力が伝達される。

【0029】カムシャフト72の端部は筒形のインナハウジング65がボルト64を介して締結される。インナハウジング65の外周に回転可能に嵌合する筒形のアウタハウジング63が設けられ、アウタハウジング63にカムプーリ71が一体形成される。

【0030】インナハウジング65とアウタハウジング63の間にはリング状のヘリカルギア73が介装される。ヘリカルギア73の内外周にヘリカルスプラインがそれぞれ形成され、各ヘリカルスプラインがインナハウジング65の外周とアウタハウジング63の内周と噛合い、ヘリカルギア73がリターンスプリング74に抗して軸方向に移動するのに伴いアウタハウジング63に対してインナハウジング65が相対回転し、カムプーリ71に対するカムシャフト72の回転方向の位相角が変化する。

【0031】インナハウジング65とアウタハウジング63とヘリカルギア73の間には油圧室75が画成される。油圧室75に導かれる油圧力が所定値を越えて上昇すると、ヘリカルギア73が所期位置からリターンスプリング74に抗して図中右方向に移動することにより、カムシャフト72は吸気弁9の開閉時期を進角させる方向に回転するようになっている。

【0032】これにより、ヘリカルギア73が初期位置にあるときは、図4に実線で示すように、吸気弁9の開閉時期が遅れ、ヘリカルギア73が最大に変位したときは、図4に破線で示すように、吸気弁9の開閉時期が進められる。

【0033】油圧室75はカムシャフト72の内部に形成された軸孔78と、シンダヘッド69に形成されたオイルギャラリ59と、オリフィス77と、シリンダブロック68に形成されたメインギャラリ58を介してオイルポンプ57からの吐出油圧が導入される。

【0034】カムシャフト72の他端にはエンジン運転条件に応じて開閉制御される電磁切換弁79が設けられる。電磁切換弁79は非通電時に図のように軸孔78を開いて油圧室75に導かれる油圧を低下させ、通電時に軸孔78を閉塞して油圧室75に導かれる油圧を高めるようになっている。

【0035】バルブリフト調整機構40とバルブタイミング調整機構70の制御手段として、電磁切換弁45と電磁切換弁79の通電を制御するコントロールユニット51が設けられる。

【0036】コントロールユニット51は、エンジン回転信号、エンジン負荷信号をはじめ、冷却水温信号、潤滑油の温度信号、過給機による吸気の過給圧力信号等を入力して、これらの検出値に基づいてエンジントルクの急激な変動を抑えつつ、バルブリフト特性の切換えを円滑に行うようになっている。

【0037】図1に示すように、コントロールユニット51は、低回転低負荷時に吸気弁9の開閉時期を遅らせるとともに、低速カム21を介して吸気弁9のリフト量を小さくし、低回転高負荷時に吸気弁9の開閉時期を進ませるとともに、低速カム21を介して吸気弁9のリフト量を小さくし、高回転時に吸気弁9の開閉時期を遅らせるとともに、高速カム22を介して吸気弁9のリフト量を大きくするようにバルブタイミング調整機構70と

バルブリフト調整機構４０を駆動する。

【００３８】コントロールユニット５１は、吸気弁９のバルブリフト特性を切換える運転時に、バルブタイミング調整機構７０とバルブリフト調整機構４０を時間差を持って切換え作動させて、切換え時に生じるエンジンのトルクショックを緩和する。

【００３９】すなわち、コントロールユニット５１は、低回転高負荷時から高回転時に移行する運転条件で、先にバルブリフト調整機構４０の電磁切換弁４５をＯＦＦからＯＮに切換えた後、バルブタイミング調整機構７０の電磁切換弁７９をＯＦＦからＯＮに切換える。そして、高回転時から低回転高負荷時に移行する運転条件で、先にバルブタイミング調整機構７０の電磁切換弁７９をＯＮからＯＦＦに切換えた後、バルブリフト調整機構４０の電磁切換弁４５をＯＮからＯＦＦに切換える。

【００４０】次に、作用について説明する。

【００４１】低回転低負荷時にバルブタイミング調整機構７０を介して吸気弁の開閉時期を遅らせるとともに、バルブリフト調整機構４０を介して吸気弁９のリフト量を小さくして、バルブオーバラップを小さくすることにより、排気ポートからシリンダへの排気の吹き返しを抑えられ、残留ガス率を低下させて燃焼を安定させ、アイドル安定性を高められるとともに、燃費の低減がはかれる。

【００４２】低回転高負荷時にバルブタイミング調整機構７０を介して吸気弁９の開閉時期を進ませることにより、シリンダに吸入された混合気が吸入行程の下死点付近で吸気ポートに吐き出されることを抑制して、吸気充填効率を高められる。このとき、バルブリフト調整機構を介して吸気弁のリフト量を小さくすることにより、バルブオーバラップが大きくなり過ぎることを回避し、残留ガスを低下させ、発生トルクを高められる。

【００４３】高回転時にバルブタイミング調整機構７０を介して吸気弁９の開閉時期を遅らせるとともに、バルブリフト調整機構４０を介して吸気弁９のリフト量を大きくすることにより、吸気の慣性過給効果を利用して吸気充填効率を高められる。しかも、バルブオーバラップを大きくすることにより、排気管内に生じる負圧波により排気の掃気効果が得られ、排気の押し出し損失を低減して出力向上がはかれる。すなわち、排気行程の後半は排気管を移動する排気ガスにより負圧が生じるとともに、オーバラップ期間中は吸気流がシリンダ内に流入することにより、排気ガスの掃気効果が高められる。

【００４４】電磁切換弁４５のＯＮ・ＯＦＦによりバルブリフト調整機構４０は瞬時に各カム２１，２２の切換えが完了するが、電磁切換弁７９のＯＮ・ＯＦＦによりバルブリフト調整機構７０によりカムシャフト７２が回転し終わるまでに０．２～１秒程度の時間がかかる。

【００４５】コントロールユニット５１は、電磁切換弁４５と電磁切換弁７９を所定の時間差を持ってＯＮ・ＯＦＦして、バルブタイミング特性とバルブリフト特性が段階的に切換えられることにより、切換え時に生じるエンジンのトルクショックを緩和することができる。

【００４６】低回転高負荷時から高回転時に移行する運転条件で、先に電磁切換弁４５をＯＦＦからＯＮに切換えて、バルブリフト調整機構４０を瞬時に切換え作動させた後、所定の時間差を持って電磁切換弁７９をＯＦＦからＯＮに切換えて、バルブタイミング調整機構７０を切換え作動させることにより、先に切換え作動速度の比較的遅いバルブタイミング調整機構７０を切換える場合に比べて、切換えに要する時間が短縮され、加速応答性を高められる。

【００４７】高回転時から低回転高負荷時に移行する運転条件で、先に電磁切換弁７９をＯＮからＯＦＦに切換えて、バルブタイミング調整機構７０を切換え作動させた後、電磁切換弁４５をＯＮからＯＦＦに切換えて、バルブリフト調整機構７０を瞬時に切換え作動させることにより、先に切換え作動速度の比較的速いバルブリフト調整機構７０を切換える場合に比べて、この切換えに要する時間が長くなり、急激に減速するショックを緩和することができる。

【００４８】また、コントロールユニット５１は、低回転高負荷時から高回転時に移行する運転条件で、バルブリフト調整機構４０の切換え作動が終了した後、バルブタイミング調整機構７０の電磁切換弁７９をＯＦＦからＯＮに切換え、高回転時から低回転高負荷時に移行する運転条件で、バルブタイミング調整機構７０の切換え作動が終了した後、バルブリフト調整機構４０の電磁切換弁４５をＯＮからＯＦＦに切換える構成としても良い。

【００４９】これにより、バルブタイミング調整機構７０とバルブリフト調整機構４０の作動終了時期に時間差を確実に持たせることができる。実際にバルブタイミング調整機構７０はその電磁切換弁７９がＯＮからＯＦＦに切換えてから、その作動を終了するまでに最大１秒程度の時間がかかるが、バルブタイミング調整機構７０はその電磁切換弁７９がＯＮからＯＦＦに切換えられてから、１秒以上の所定時間が経過してから、バルブリフト調整機構４０の電磁切換弁４５をＯＮからＯＦＦに切換えれば良い。

【００５０】

【発明の効果】以上説明したように本発明は、吸気弁を開閉駆動する吸気側カムシャフトと、クランクシャフトに対する吸気側カムシャフトの位相角を変えるバルブタイミング調整機構と、互いに異なるプロフィールを有する複数のカムと、吸気弁を開閉駆動するカムを切換えるバルブリフト調整機構と、エンジンの運転条件を検出する手段と、エンジンの運転条件に応じてバルブタイミング調整機構とバルブリフト調整機構を駆動する制御手段とを備えたエンジンの可変動弁装置にあって、制御手段を、低回転低負荷時にバルブタイミング調整機構を介し

て吸気弁の開閉時期を遅らせるとともに、バルブリフト調整機構を介して吸気弁のリフト量を小さくし、低回転高負荷時にバルブタイミング調整機構を介して吸気弁の開閉時期を進ませるとともに、バルブリフト調整機構を介して吸気弁のリフト量を小さくし、高回転時にバルブタイミング調整機構を介して吸気弁の開閉時期を遅らせるとともに、バルブリフト調整機構を介して吸気弁のリフト量を大きくする構成としたため、広い運転範囲に渡って吸気弁のバルブリフト特性を適正に制御して、低中回転時のトルク向上と高回転時の出力向上を両立することができる。

【００５１】請求項２記載の発明においては、吸気弁のバルブリフト特性を切換える運転時に、バルブタイミング調整機構とバルブリフト調整機構を時間差を持って切換え作動させる構成のため、バルブタイミング特性とバルブリフト特性が段階的に切換えれることにより、切換え時に生じるエンジンのトルクショックを緩和することができる。

【００５２】請求項３記載の発明においは、低回転高負荷時から高回転時に移行する運転条件で、先にバルブリフト調整機構を切換え作動させた後、バルブタイミング調整機構を切換え作動させ、高回転時から低回転高負荷時に移行する運転条件で、先にバルブタイミング調整機構を切換え作動させた後、バルブリフト調整機構を切換え作動させる構成としたため、加速応答性を高めるとともに、急激に減速するショックを緩和することができる。

【図面の簡単な説明】

【図１】本発明の実施例において、バルブリフト特性を切換える制御内容を示す特性図。

【図２】同じく本発明の実施例を示す機械的構成図。

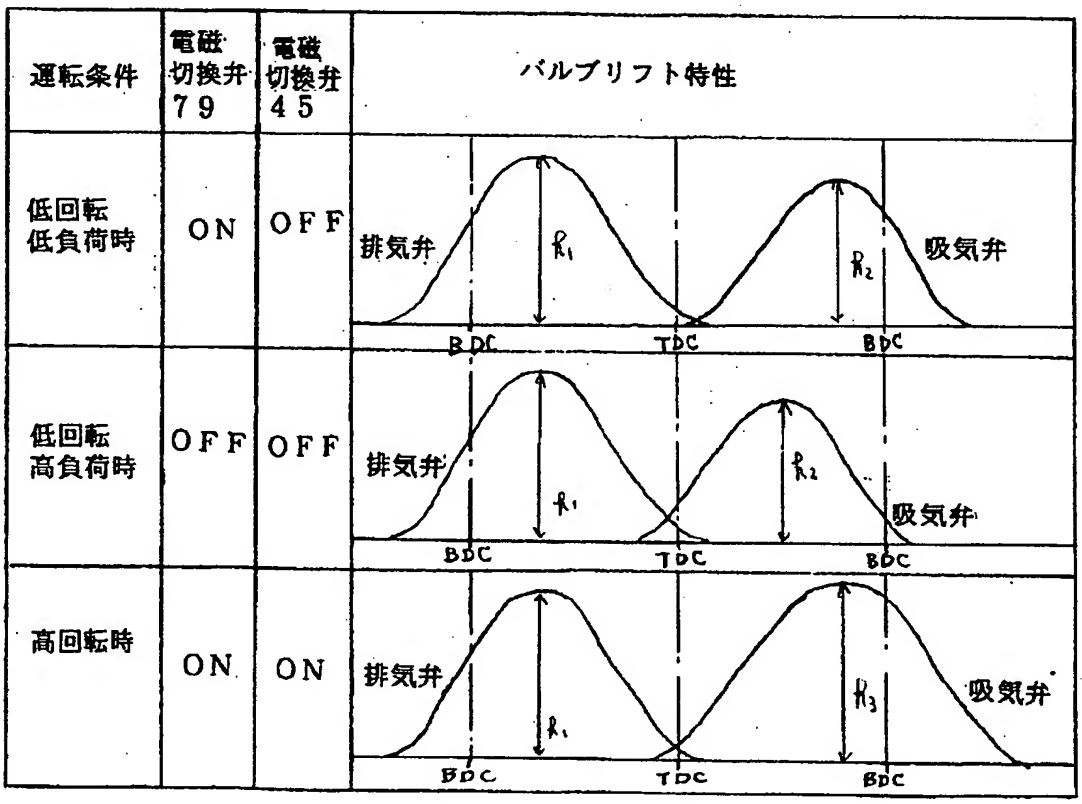
【図３】同じく図２のＸ－Ｘ線に沿う断面図。

【図４】同じくバルブリフト特性の切換え特性図。

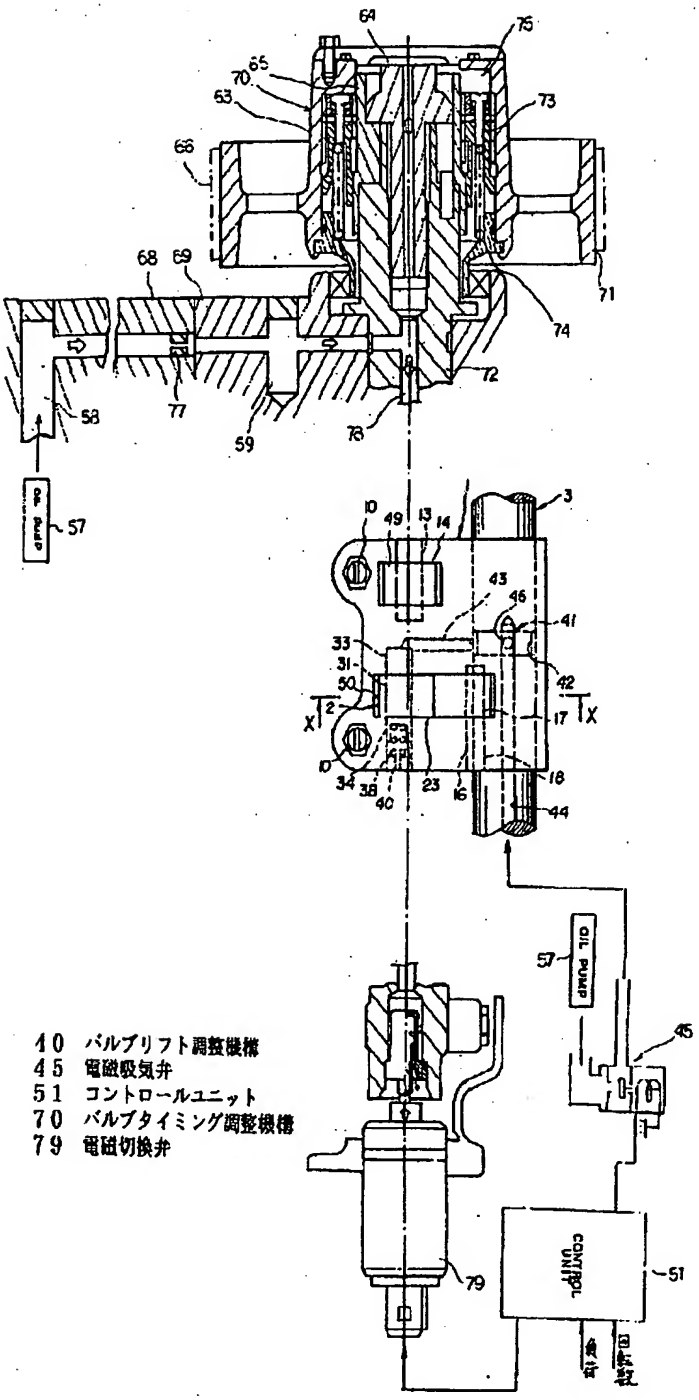
【符号の説明】

４０　バルブリフト調整機構
４５　電磁吸気弁
５１　コントロールユニット
７０　バルブタイミング調整機構
７９　電磁切換弁

【図１】

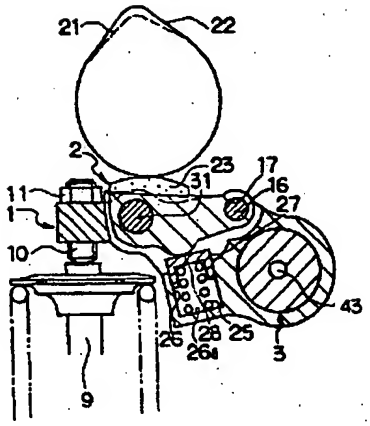


【図2】

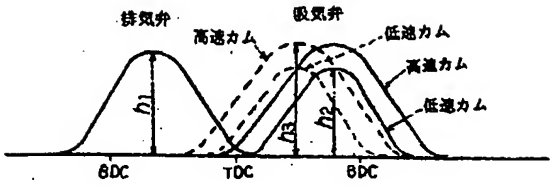


10　バルブリフト調整機構
45　電磁吸気弁
51　コントロールユニット
70　バルブタイミング調整機構
79　電磁切換弁

【図3】



【図４】



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(54) Title of the Invention: VARIABLE VALVE DEVICE FOR ENGINE

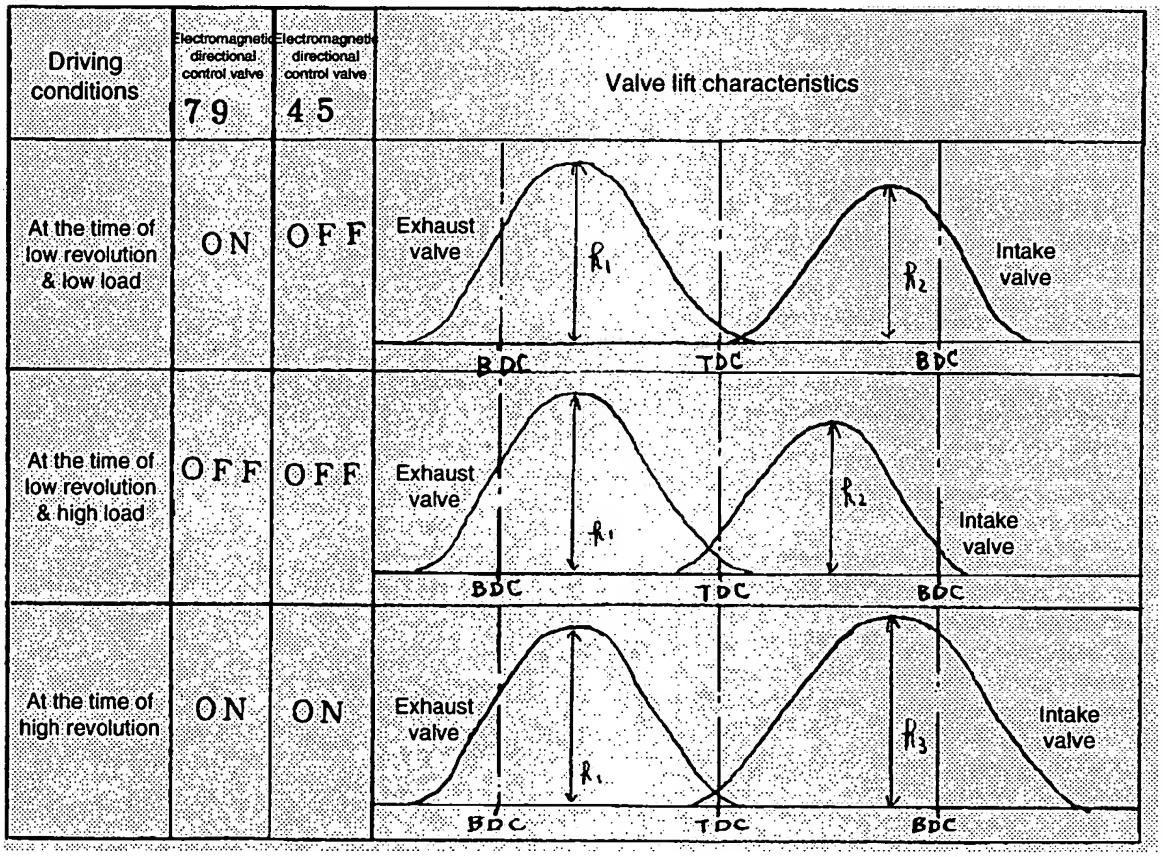
(57) Abstract:

Objective

To provide a variable valve device for controlling the valve lift characteristics of an intake valve according to operating conditions.

Construction

[The present invention] is equipped with a valve timing adjustment mechanism to change the phase angle of an intake camshaft relative to a crank shaft, and a valve lift adjustment mechanism to selectively switch between multiple cams having a different profile and to change the lift height of the intake valve, wherein a control unit is constructed by delaying the opening/closing timing of the intake valve at the time of low rpm & low load, and concurrently lessening the lift height of the intake valve; by advancing the opening/closing timing of the intake valve at the time of low rpm & high load, and concurrently lessening the lift height of the intake valve; and by delaying the opening/closing timing of the intake valve at the time of high rpm, and concurrently increasing the lift height of the intake valve at the time of high rpm.



What is claimed is

1. A variable valve device for an engine, wherein, the variable valve device for an engine is a variable valve device for an engine equipped with an intake-side camshaft to drive the opening/closing of an intake valve, a valve timing adjustment mechanism to change the phase angle of the intake-side camshaft relative to a crankshaft, multiple cams having a different profile, a valve lift adjustment mechanism to switch between cams driving the opening/closing of the intake valve, a means to detect the engine operating conditions, and a control means to drive the valve timing adjustment mechanism and the valve lift adjustment mechanism according to the engine operating conditions, wherein a control means is constructed by delaying the opening/closing timing of the intake valve via the valve timing adjustment mechanism at the time of low rpm & low load, and concurrently lessening the lift height of the intake valve via the valve lift adjustment mechanism; by advancing the opening/closing timing of the intake valve via the valve timing adjustment mechanism at the time of low rpm & high load, and concurrently lessening the lift height of the intake valve via the valve lift adjustment mechanism; and by delaying the opening/closing timing of the intake valve via the valve timing adjustment mechanism at the time of high rpm, and concurrently increasing the lift height of the intake valve via the valve lift adjustment mechanism.

2. The variable valve device for an engine according to Claim 1, wherein, the control means is constructed by switching and operating between the valve timing adjustment mechanism and the valve lift adjustment mechanism having a time difference at the time of switching between the valve lift characteristics of the intake valve.

3. The variable valve device for engine according to Claim 2, wherein, the control means is constructed such that after switching to the valve lift adjustment mechanism and operating the mechanism are performed first under operating conditions to shift from low rpm & high load to high rpm, switching to the valve timing adjustment mechanism and operating the mechanism are performed, and, after switching to the valve timing adjustment mechanism and operating the mechanism are performed first under the operating conditions to shift from high rpm to low rpm & high load, switching to the valve lift adjustment mechanism and operating the mechanism are performed.

4. The variable valve device for engine according to Claim 3, wherein, the control means is constructed such that after switching to the valve lift adjustment mechanism and operating the mechanism are completed under operating conditions to shift from low rpm & high load to high rpm, switching to the valve timing adjustment mechanism and operating the mechanism are performed, and after switching to the valve timing adjustment mechanism and operating the mechanism are completed under operating conditions to shift from at high rpm to low rpm & high load, a switch is made to the valve lift adjustment mechanism and the mechanism is operated.

DETAILED DESCRIPTION OF THE INVENTION

[0001]

Industrial Field:

The present invention relates to a variable valve device for controlling the valve lift characteristics of an intake valve according to engine operating conditions.

[0002]

Prior art and related problems:

It is conventionally known that cams engaged in opening/closing an intake valve or an exhaust valve according to operating conditions are selectively switched, resulting in controlling the intake/exhaust timing or intake/exhaust volume (for example, Japanese Patent Application Laid-Open Nos. 63-167016 and 63-57805).

[0003]

In explaining this, a low-speed rocker arm whose oscillating end comes into contact with a valve, and, a high-speed rocker arm adjacent to one side of the low-speed rocker arm and not having any contact with the valve are oscillatably supported by a common rocker shaft, and a low-speed cam abrades the low-speed rocker arm and a high-speed cam having a profile in which an open valve angle or a valve lift height is greater than that of the low-speed cam abrading the high-speed rocker arm.

[0004]

In addition, in the oscillating section apart from the rocker shaft by a pre-determined distance, fitting/coming off a plunger reacting by an operational hydraulic pressure into/from a fitting hole results in the connection/disconnection of two rocker arms in a direction parallel to the rocker shaft.

[0005]

Problems Overcome by the Invention:

However, in the conventional device to selectively switch between multiple cams according to engine operating conditions, because it is necessary to set an open valve period by the low-speed cam within the range of an open valve period by the high-speed cam, for example, if an attempt is made to advance the close valve period of the intake valve in order to control the gas mixture intaken by a cylinder in the low rpm & high-load range to be discharged into an intake port in the vicinity of bottom dead center during the intake process, the open valve period is decreased and filling efficiency deteriorates, with

the problem that that a torque decline may occur in the vicinity of the number of revolutions to switch from a low-speed cam to a high-speed cam.

[0006]

Focusing upon this problem, the objective of the present invention is to provide a variable valve device to properly control the valve lift characteristics of an intake valve according to operating conditions.

[0007]

Problem Resolution Means:

The present invention comprises a variable valve device for an engine equipped with an intake-side camshaft to drive the opening/closing of an intake valve, a valve timing adjustment mechanism to change the phase angle of the intake-side camshaft relative to the crankshaft, with multiple cams having a different profile, a valve lift adjustment mechanism to switch between the cams driving the opening/closing of the intake valve, a means to detect engine operating conditions, and a control means to drive the valve timing adjustment mechanism and the valve lift adjustment mechanism according to the engine operating conditions, the control means being constructed by delaying the opening/closing timing of the intake valve via the valve timing adjustment mechanism at the time of low rpm & low load, and concurrently lessening the lift height of the intake valve via the valve lift adjustment mechanism; by advancing the opening/closing timing of the intake valve via the valve timing adjustment mechanism at the time of low rpm & high load, and concurrently lessening the lift height of the intake valve via the valve lift adjustment mechanism; and by delaying the opening/closing timing of the intake valve via the valve timing adjustment mechanism at the time of high rpm, and concurrently increasing the lift height of the intake valve via the valve lift adjustment mechanism.

[0008]

In the invention according to Claim 2, the control means is constructed by switching and operating between the valve timing adjustment mechanism and the valve lift adjustment mechanism having a time difference at the time of the switching between the valve lift characteristics of the intake valve.

[0009]

In the invention according to Claim 3, the control means is constructed such that after switching to the valve lift adjustment mechanism and operating the mechanism are performed first under the operating conditions to shift from low rpm & high load to high rpm, switching to the valve timing adjustment mechanism and operating the mechanism are performed, and after switching to the valve timing adjustment mechanism and operating the mechanism are performed first under the operating conditions to shift from

high rpm to low rpm & high load, switching to the valve lift adjustment mechanism and operating the mechanism are performed.

[0010]

In the invention according to Claim 4, the control means is constructed such that after switching to the valve lift adjustment mechanism and operating the mechanism are completed under the operating conditions to shift from low rpm & high load to high rpm, switching to the valve timing adjustment mechanism and operating the mechanism are performed, and after switching to the valve timing adjustment mechanism and operating the mechanism are completed under the operating conditions to shift from high rpm to low rpm & high load, switching to the valve lift adjustment mechanism and operating the mechanism are performed.

[0011]

Operation:

Delaying the opening/closing timing of the intake valve via the valve timing adjustment mechanism at the time of low rpm & low load, and concurrently lessening the lift height of the intake valve via the valve lift adjustment mechanism and lessening the valve overlap result in the restraint of the exhaust [gas] to be blown back from the exhaust port into a cylinder, the lowering of the remainder gas ratio, the stabilization of combustion, and the enhancement of the idling stability; concurrently, the reduction of fuel consumption.

[0012]

Advancing the opening/closing timing of the intake valve at the time of low rpm & high load via the valve timing adjustment mechanism results in controlling the gas mixture intaken by the cylinder to be discharged into the intake port in the vicinity of bottom dead center during the intake process and the enhancement of the intake filling efficiency. At this time, lessening the lift height of the intake valve via the valve lift adjustment avoids excessive valve overlap, lowers the remaining gas and increases the generated torque.

[0013]

Delaying the opening/closing timing of the intake valve at the time of high rpm via the valve timing adjustment mechanism, and concurrently increasing the lift height of the intake valve via the valve lift adjustment mechanism results in increasing the intake filling efficiency by utilizing the inertia supercharging effect of the intake. In addition, increasing the valve overlap enables obtaining a scavenging effect of the exhaust [gas] due to a negative pressure wave generated within an exhaust pipe, the reduction of the exhaust [gas] loss from being forced out and improved output. In other words, negative pressure is generated due to the exhaust gas migration within the exhaust pipe in the second half of the exhaust process. Concurrently, inflow of the intake airflow into the

cylinder during the overlapping period results in the enhancement of the exhaust gas scavenging effect.

[0014]

In the invention according to Claim 2, because it is constructed so that switching between the valve timing adjustment mechanism and the valve lift adjustment mechanism by having a time difference when operating to switch between the valve lift characteristics of the intake valve, and switching between the valve timing characteristic and the valve lift characteristic by stages enables the mitigation of the engine torque shock to be generated at the time of switching.

[0015]

In the invention according to Claim 3, after switching to the valve lift adjustment mechanism and operating the mechanism are performed first under the driving conditions to shift from low rpm & high load to high rpm, switching to the valve timing adjustment mechanism and operating the mechanism results in the reduction of the time period required for switching and the enhancement of the acceleration response compared to the case of first switching to the valve timing adjustment mechanism, which has a comparatively slow switching operation speed.

[0016]

After switching to the valve timing adjustment mechanism and operating the mechanism are performed first under the operating conditions to shift from high rpm to low rpm & high load, switching to the valve lift adjustment mechanism and operating the mechanism enable the prolongation of the time period required for this switching and the mitigation of shock due to rapid deceleration compared to a case of first switching to the valve lift adjustment mechanism, which has a comparatively fast switching operation speed.

[0017]

In the invention according to Claim 4, after switching to the valve lift adjustment mechanism or the valve timing adjustment mechanism and operating the mechanism are completed first according to the operating conditions, switching to the valve timing adjustment mechanism or the valve lift adjustment mechanism and operating the mechanism enable a secure provision of a time difference in the operation completion timings between the valve timing adjustment mechanism and the valve lift adjustment mechanism, respectively.

[0018]

Embodiment:

Figs. 2 and 3 show the mechanical construction of an embodiment of the present invention.

[0019]

A valve lift adjustment mechanism 40 is described first. A single unit main rocker arm 1 is established at each cylinder by corresponding to two intake valves 9. A base end of the main rocker arm 1 is oscillatably supported by a cylinder head 69 via a main rocker shaft 3 in common with each cylinder, and adjustment screws 10 having the stem top of each intake valve 9 come into contact are fastened to the end of the main rocker arm 1 via nuts 11.

[0020]

A roller 14 rotatably connects the main rocker arm 1 to the shaft 13 via a needle bearing, and is designed such that a low-speed cam 21 makes contact with the roller 14 while it rotates.

[0021]

The main rocker arm 1 is formed to be roughly rectangular on the top view, and a sub-rocker arm 2 is established in parallel to the roller 14. The base end of the sub-rocker arm 2 connects the main rocker arm 2 [sic. '1'?] to be relatively rotatable relative to the main locker arm 2 [sic.] via a sub-rocker shaft 16. The sub-rocker shaft 16 is slidably fitted into a hole 17 formed in the sub-rocker arm 2, and in the meantime, is press-fitted into a hole 18 formed in the main rocker arms 1, respectively.

[0022]

The sub-rocker arm 2 does not have any section contacting the intake valve 9, and a cam follower 23 sliding onto the high-speed cam 22 is formed by an arc-like projection at the end, and a lost motion spring 25 pressing the cam follower 23 to the high-speed cam 22 is disposed at the lower side.

[0023]

A cylindrical concave portion 26, positioned immediately below the sub-rocker arm 2, where the lost motion spring 25 is disposed, is integrally formed in the main rocker arm 1. The lower end of the coil-state lost motion spring 25 is situated on a bottom surface 26a of the concave portion 26, and its upper end comes into contact with a follower 28, which is integrally formed in the sub-rocker arm 2 via a retainer 27, slidably fitting into the concave portion 26.

[0024]

The low-speed cam 21 and the high-speed cam 22 are integrally formed in the common camshaft 72, respectively, and are formed to have a different shape (also including a similar figure with different size) to satisfy the valve lift characteristics required at the time of low rpm and high rpm of the engine. In this embodiment, as shown in Fig. 4, the high-speed cam 22 has a profile where both the valve lift height and the valve opening period are increased compared to that of the low-speed cam 21. Herein, both the valve lift height and the valve opening period are expanded. Furthermore, when the lift height of the cam to drive the exhaust valve is 'h1', the lift height of the high-speed cam 22 is 'h3' and the lift height of the low-speed cam 21 is 'h2', there is a relationship, h3 > h1 > h2.

[0025]

As a connection driving means enabling the locking of the relative rotation of both rocker arms 1 and 2, plungers 33, 31 and 34 are slidably fitted across the main rocker arm 1 and the sub-rocker arm 2, and a hydraulic path 43 connects behind the plunger 33; in the meantime, a return spring 38 is disposed behind the plunger 34.

[0026]

If the operational hydraulic pressure led from the hydraulic path 43 is low, the plungers 33 and 31 fit into the sub-rocker arm 2 and the main rocker arm 1, respectively, and the oscillation of both are not restrained. In the meantime, when the operational hydraulic pressure led from the hydraulic path 43 ascends, the plungers 33 and 31 slide while compressing the return spring 38, and fit into and throughout the main rocker arm 1 and the sub-rocker arm 2, integrating the oscillation of both.

[0027]

The hydraulic path 43 is established through the inside of the main rocker arm 1 and the main rocker shaft 3, and the discharged hydraulic pressure of an oil pump 57 is led via an electromagnetic directional control valve 45 at the pre-determined high rpm.

[0028]

Valve timing adjustment mechanism 70 is described next. The valve timing adjustment mechanism 70 is established between a camshaft 72 and a cam pulley 71, and is designed to change the phase angle of both and to change the opening/closing timing of the intake valve 9 according to the operating conditions. Torque from a crank shaft (un-shown) is transmitted to the cam pulley 71 via a timing belt 66.

[0029]

A barrel inner housing 65 is fastened at the end of the camshaft 72 via a bolt 64. A barrel outer housing 63 rotatably fitting into the outer circumference of the inner housing 65 is established, and the cam pulley 71 is integrally formed in the outer housing 63.

[0030]

A ring-state helical gear 73 is disposed between the inner housing 65 and the outer housing 63. Helical splines are formed around the inner and outer circumferences of the helical gear 73, respectively, and each helical spline is engaged with the outer circumference of the inner housing 65 and the inner circumference of the outer housing 63. Accompanied with the shift of the helical gear 73 resisted by the return spring 74, the inner housing 65 relatively rotates relative to the outer housing 63, and the phase angle of the camshaft 72 in the rotative direction relative to the cam pulley 71 is changed.

[0031]

A hydraulic chamber 75 is partitioned within the inner housing 65, the outer housing 63 and the helical gear 73. When the hydraulic pressure led to the hydraulic chamber 75 ascends beyond a pre-determined value, the movement of the helical gear 73 resisted by the return spring 74 toward the right direction in the diagram from the desired position [sic.] results in the revolution of the camshaft 72 in the direction where the opening/closing timing of the intake valve 9 is advanced.

[0032]

With this design, when the helical gear 73 is located at the initial position [sic.], the opening/closing timing of the intake valve 9 is delayed as shown by the solid line in Fig. 4, and when the helical gear 73 is displaced at maximum, the opening/closing timing of the intake valve 9 is advanced as shown by the broken line in Fig. 4.

[0033]

Discharged hydraulic pressure from the oil pump is induced into the hydraulic chamber 75 via an axial hole 78 formed inside the camshaft 72, an oil gallery 59 formed in the cylinder head 69, an orifice 77, and a main gallery 58 formed in cylinder block 68.

[0034]

The electromagnetic directional control valve 79 where opening/closing is controlled according to the engine operating conditions is established at the other end of the camshaft 72, and is designed so that the electromagnetic directional control valve 79 lowers the hydraulic pressure led to the hydraulic chamber 75 by opening the axial hole 78 at the time of non-electric conduction as shown in the chart, and increases the hydraulic pressure led to the hydraulic chamber 75 by blocking the axial hole 78 at the time of electric conduction.

[0035]

As a control means of the valve lift adjustment mechanism 40 and the valve timing adjustment mechanism 70, a control unit 51 is established for controlling electric conduction of the electromagnetic directional control valves 45 and 79.

[0036]

The control unit 51 is designed so that a cooling water temperature signal, a temperature signal of lubricating oil and a supercharging pressure signal of the intake by a supercharger are entered, and while rapid fluctuation of the engine torque is restrained based upon these detected values, the valve lift characteristic is smoothly switched.

[0037]

As shown in Fig. 1, the control unit 51 controls the valve timing adjustment mechanism 70 and the valve lift adjustment mechanism 40 to delay the opening/closing timing of the intake valve 9 at the time of low rpm & low load, and concurrently to lessen the lift height of the intake valve 9 via the low-speed cam 21; to advance the opening/closing timing of the intake valve 9 at the time of low rpm & high load, and concurrently to lessen the lift height of the intake valve 9 via the low-speed cam 21; and, to delay the opening/closing timing of the intake valve 9 at the time of high rpm, and concurrently to increase the lift height of the intake valve 9 via the high-speed cam 22.

[0038]

The control unit 51 operates to switch between the valve timing adjustment mechanism 70 and the valve lift adjustment mechanism 40 by having a time difference at the time of switching between the valve lift characteristics of the intake valve 9, and the torque shock to be generated at the time of switching is mitigated.

[0039]

In other words, after the control unit 51 switches the electromagnetic directional control valve 45 of the valve lift control mechanism 40 from OFF to ON first under the operating conditions to shift from low rpm & high load to high rpm, it switches the electromagnetic directional control valve 79 of the valve timing adjustment mechanism 70 from OFF to ON. Then, after [the control unit 51] switches the electromagnetic directional control valve 79 of the valve timing adjustment mechanism 70 from ON to OFF first under the operating conditions to shift from high rpm to low rpm & high load, it switches the electromagnetic directional control valve 45 of the valve lift adjustment mechanism 40 from ON to OFF.

[0040]

The operation is described next.

[0041]

Delaying the opening/closing timing of the intake valve [9] via the valve timing adjustment mechanism 70 at the time of low rpm & low load, and concurrently lessening the lift height of the intake valve 9 via the valve lift adjustment mechanism 40 and lessening the valve overlap result in the restraint of the exhaust (gases) blown back into the cylinder from the exhaust port, the reduction of the remaining gas ratio, the stabilization of combustion and the enhancement of idling stability; and concurrently, the reduction of fuel cost.

[0042]

Advancing the opening/closing timing of the intake valve 9 via the valve timing adjustment mechanism 70 at the time of low rpm & high load results restraining the discharge of the gas mixture intaken by the cylinder into the intake port in the vicinity of bottom dead center during the intake process and the enhancement of the intake filling efficiency. At this time, lessening the lift height of the intake valve via the valve lift adjustment mechanism avoids excessive valve overlap, reduces the amount of remaining gas and increases the generated torque.

[0043]

Delaying the opening/closing timing of the intake valve 9 via the valve timing adjustment mechanism 70 at the time of high rpm, and concurrently increasing the lift height of the intake valve 9 via the valve lift adjustment mechanism 40 result enhancing the intake filling efficiency by utilizing the inertia supercharging of intake. In addition, increasing the valve overlap enables obtaining the exhaust (gas) scavenging effect due to a negative pressure wave generated within the exhaust pipe, reducing the loss of exhaust [gas] due to being forced out and improved output. In other words, negative pressure is generated in the second half of the exhaust process due to the exhaust gas migration within the exhaust pipe, and concurrently, inflow of intake airflow into the cylinder during the overlap period result in enhancing the exhaust gas scavenging effect.

[0044]

The valve lift adjustment mechanism 40 instantaneously completes the switch between each of the cams 21 and 22 due to turning ON/OFF the electromagnetic directional control valve 45. However, it takes approximately 0.2 to 1 seconds to completion to revolve the camshaft 72 by the valve lift adjustment mechanism 70 due to switching ON/OFF the electromagnetic switch valve 79.

[0045]

In the control unit 51, switching the electromagnetic directional control valves 45 and 79 ON & OFF by having a time difference and switching between the valve timing characteristic and the valve lift characteristic by stages enable the mitigation of the engine torque shock generated at the time of switching.

[0046]

The electromagnetic valve 45 is switched from OFF to ON first under the operating conditions to shift from low rpm & high load to high rpm, and after instantaneous switching to the valve lift adjustment mechanism 40 and operating the mechanism are performed, switching the electromagnetic direction control valve 79 from OFF to ON by having a pre-determined time difference and switching to the valve timing adjustment mechanism 70 and operating the mechanism result in the reduction of the time period required for switching and the enhancement of the acceleration response, compared to a case of first switching to the valve timing adjustment mechanism 70, which has a comparatively slow switch operation speed.

[0047]

The electromagnetic directional control valve 79 is switched from ON to OFF first under the operating conditions to shift high rpm to low rpm & high load, and after switching the valve timing adjustment mechanism 70 and operating the mechanism are performed, the electromagnetic directional control valve 45 is switched from ON to OFF and instantaneous switching to the valve lift adjustment mechanism 70 and operating the mechanism are performed. This design enables the prolongation of the time period required for this switching and the mitigation of shock of rapid deceleration, compared to a case of first switching to the valve lift adjustment mechanism 70, which has a comparatively fast switching operation speed.

[0048]

Further, the control unit 51 can be constructed such that after switching to the valve lift adjustment mechanism 40 and operating the mechanism are completed under the operating conditions to shift from low rpm & high load to high rpm, the electromagnetic directional control valve 79 of the valve timing adjustment mechanism 70 is switched from OFF to ON, and after switching to the valve timing adjustment mechanism 70 and operating the mechanism are completed under the operating conditions to shift from high rpm to low rpm & high load, the electromagnetic directional control valve 45 of the valve lift adjustment mechanism 40 is switched from ON to OFF.

[0049]

This construction enables the secure provision of a time difference to the operation completion timings between the valve timing adjustment mechanism 70 and the valve lift adjustment mechanism 40. In actuality, it takes approximately 1 second at maximum for the valve timing adjustment mechanism 70 to complete the operation after switching the electromagnetic directional control valve 79 from ON to OFF. However, after a pre-determined time period, which is 1 second or longer, has passed after switching the electromagnetic directional control valve 79 in the valve timing adjustment mechanism 70 from ON to OFF, the electromagnetic directional control valve 45 of the valve lift adjustment mechanism 40 can be switched from ON to OFF.

[0050]

Efficacy of the Invention:

As described above, the present invention comprises a variable valve device equipped with the intake-side camshaft to drive the opening/closing of the intake valve, the valve timing adjustment mechanism to change the phase angle of the intake-side camshaft relative to the crank shaft, the multiple cams having a different profile, the valve lift adjustment mechanism to switch between the cams to drive the opening/closing of the intake valve, the means to detect the engine operating conditions, and the control means to drive the valve timing adjustment mechanism and the valve lift adjustment mechanism according to the engine operating conditions, and, the control means is constructed by delaying the opening/closing timing of the intake valve via the valve timing adjustment mechanism at the time of low rpm & low load, and concurrently lessening the lift height of the intake valve via the valve lift adjustment mechanism; by advancing the opening/closing timing of the intake valve via the valve timing adjustment mechanism at the time of low rpm & high load, and concurrently lessening the lift height of the intake valve via the valve lift adjustment mechanism; and by delaying the opening/closing timing of the intake valve via the valve timing adjustment mechanism at the time of high rpm, and concurrently increasing the lift height of the intake valve via the valve lift adjustment mechanism, so the valve lift characteristics of the intake valve can be properly controlled throughout a wide operation range, and both the torque improvement at the time of low/medium revolution and the output improvement at the time of high rpm can be accomplished.

[0051]

The invention according to Claim 2 is constructed by switching and operating between the valve timing adjustment mechanism and the valve lift adjustment mechanism by having a time difference when operating to switch between the valve lift characteristics of the intake valve, so switching between the valve timing characteristic and the valve lift characteristic by stages enables the mitigation of the engine torque shock to be generated at the time of switching.

[0052]

The invention according to Claim 3 is constructed such that after switching to the valve lift adjustment mechanism and operating the mechanism are performed first under the operating conditions to shift low rpm & high load to high rpm, switching to the valve timing adjustment mechanism and operating the mechanism are performed, and, after switching to the valve timing adjustment mechanism and operating the mechanism are performed first under the operating conditions to shift from high rpm to low rpm & high load, switching to the valve lift adjustment mechanism and operating the mechanism are performed, so the acceleration response is enhanced. Concurrently, a shock due to rapid deceleration can be mitigated.

BRIEF DESCRIPTION OF DRAWING

Fig. 1 is a characteristic diagram showing the control details to switch between the valve lift characteristics in the embodiment of the present invention.

Fig. 2 is a mechanical block diagram showing the embodiment of the present invention.

Fig. 3 is a cross-sectional view along the X-X line in Fig. 2 showing the embodiment of the present invention.

Fig. 4 is a switching characteristic diagram of the valve lift characteristics showing an embodiment of the present invention.

Description of symbols:

valve lift adjustment mechanism
electromagnetic intake valve [sic.; Translator's note: ' electromagnetic directional control valve' according to the contents of Specification]
control unit
valve timing adjustment mechanism
79 electromagnetic directional control valve

Fig. 1

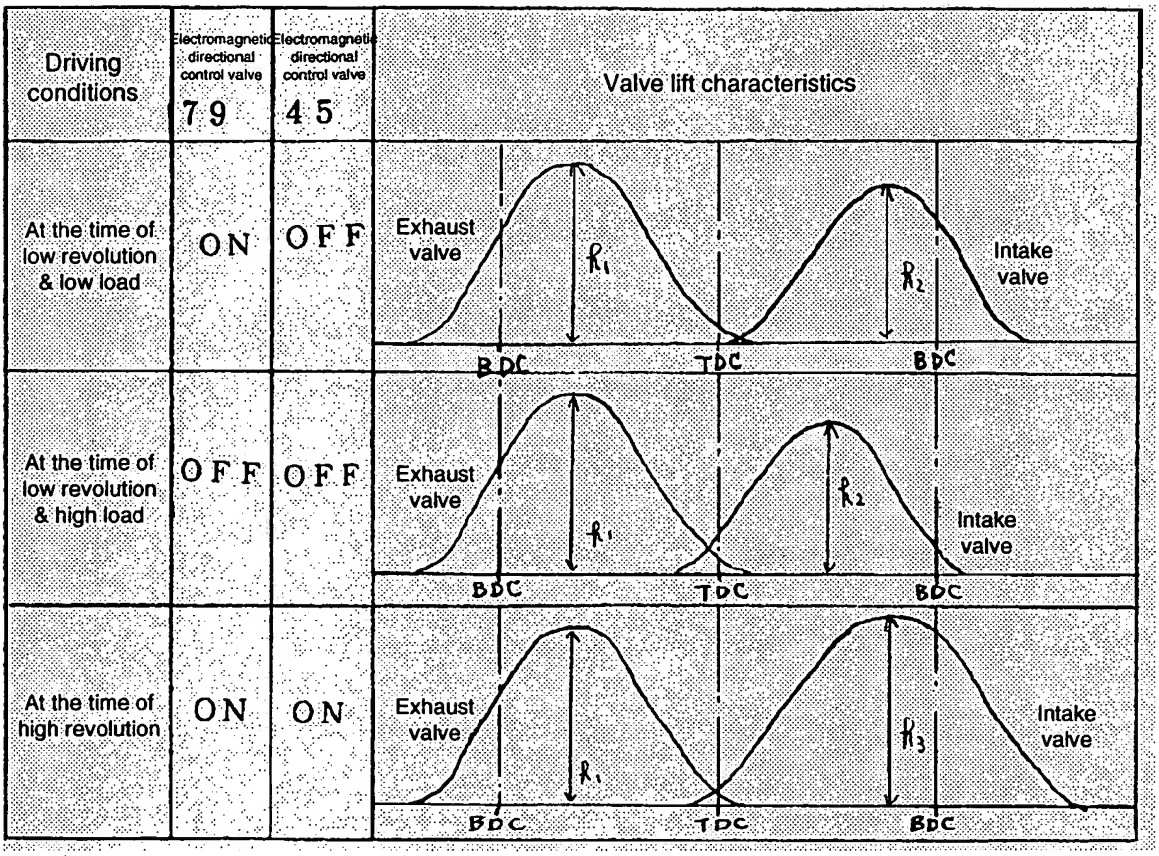

Driving conditions
Electromagnetic directional control valve 79
Electromagnetic directional control valve 45
Valve lift characteristics
At the time of low revolution & low load
ON
OFF
Exhaust valve
Intake valve
BDC
TDC
BDC
At the time of low revolution & high load
OFF
OFF
Exhaust valve
Intake valve
BDC
TDC
BDC
At the time of high revolution
ON
ON
Exhaust valve
Intake valve
BDC
TDC
BDC

Fig. 2

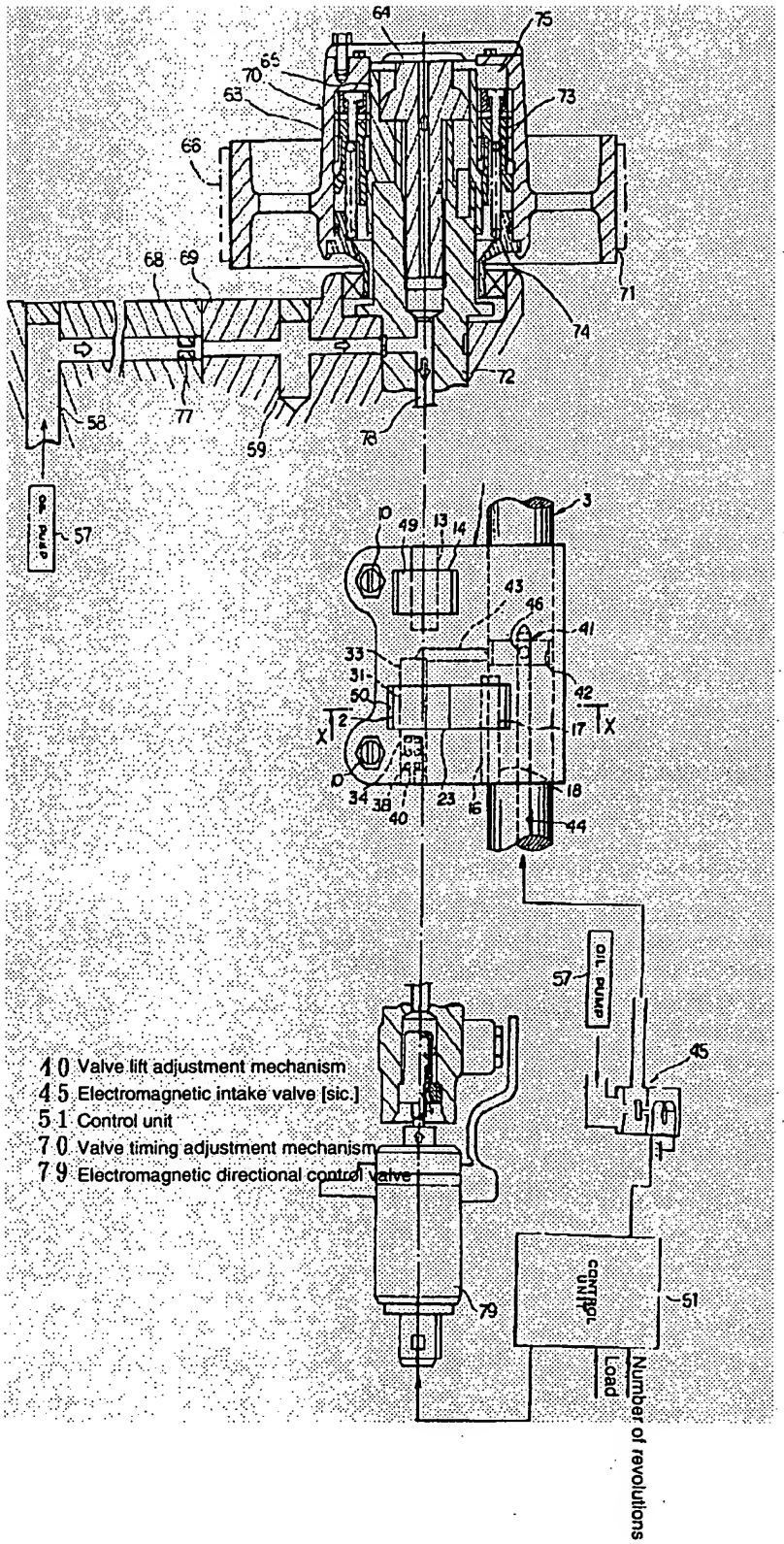

10 Valve lift adjustment mechanism
45 Electromagnetic intake valve [sic.]
51 Control unit
70 Valve timing adjustment mechanism
79 Electromagnetic directional control valve
OIL PUMP
CONTROL UNIT
Load
Number of revolutions

Fig. 3

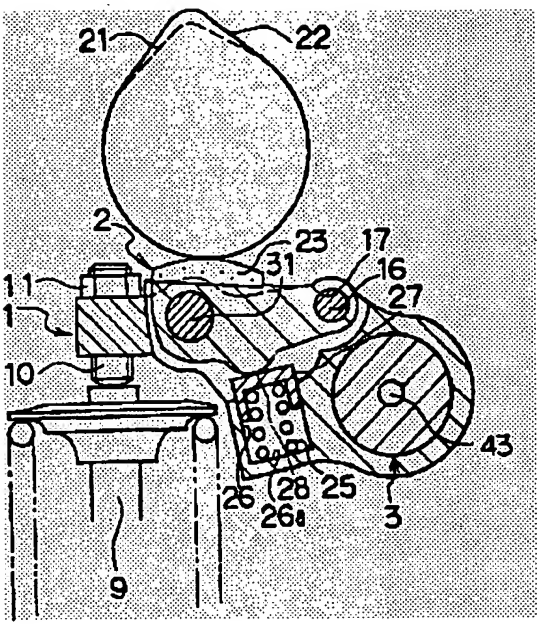
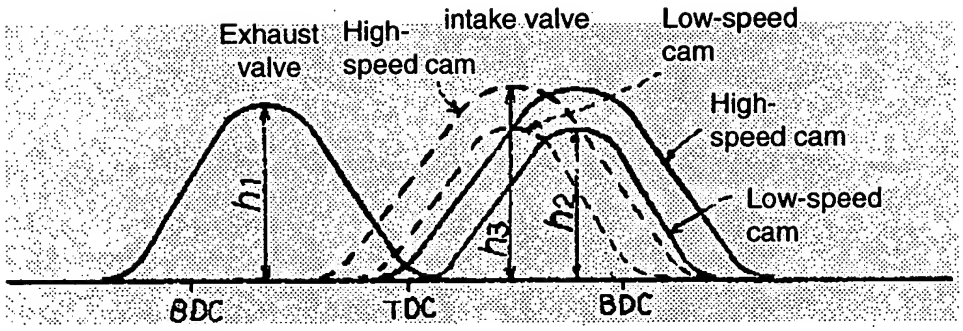

21
22
2
23
17
31
16
11
27
1
10
43
26
28
25
26a
3
9

Fig. 4


Exhaust valve
High-speed cam
intake valve
Low-speed cam
High-speed cam
Low-speed cam
h1
h3
h2
BDC
TDC
BDC